Wisconsin River Basin Modeling:

Status Updates and Technological Innovations Used in Water Quality Modeling

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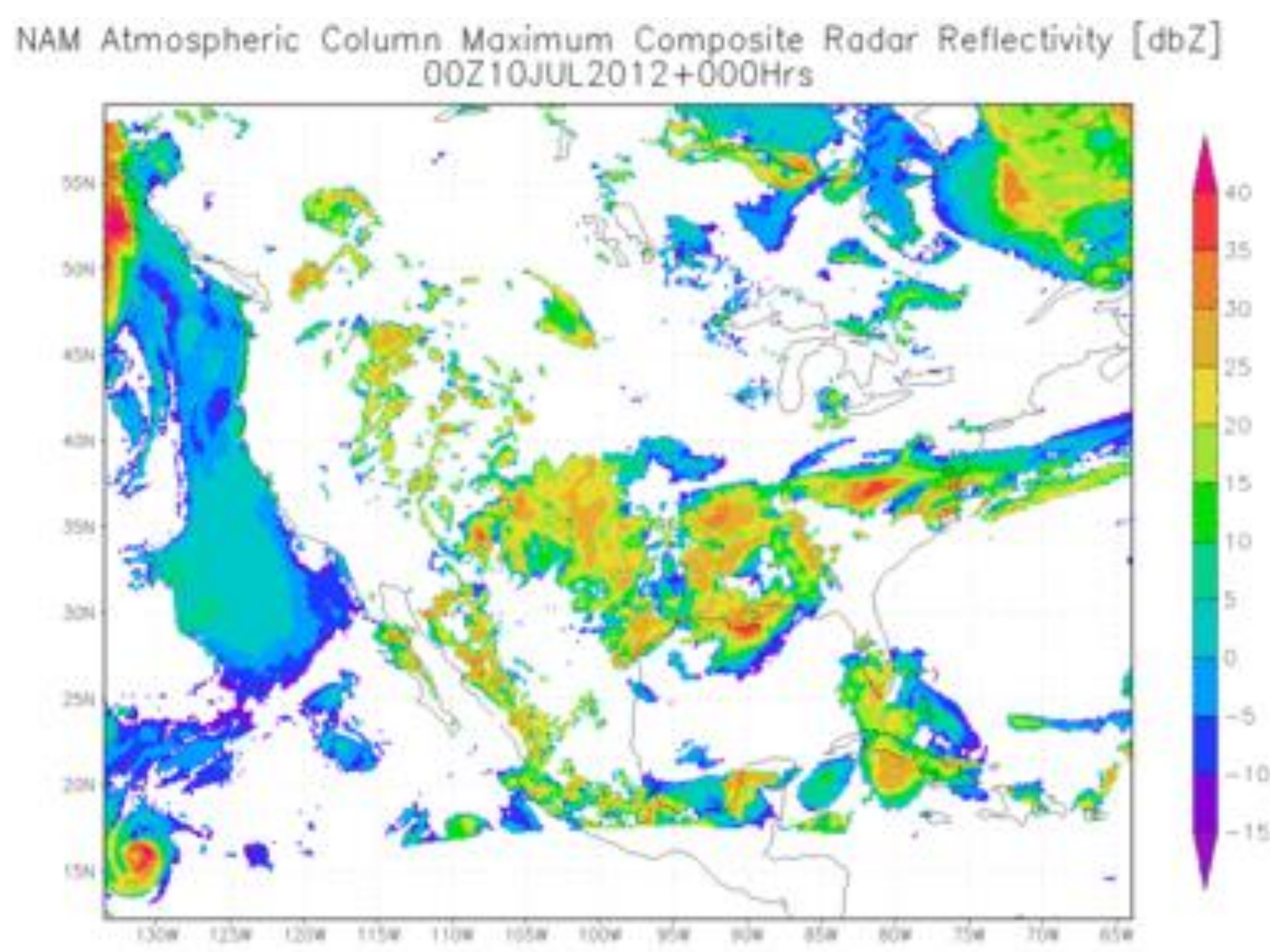
Wisconsin Department of Natural Resources

Wisconsin River Water Quality Improvement Symposium
Stevens Point, WI
March 19, 2015

Overview

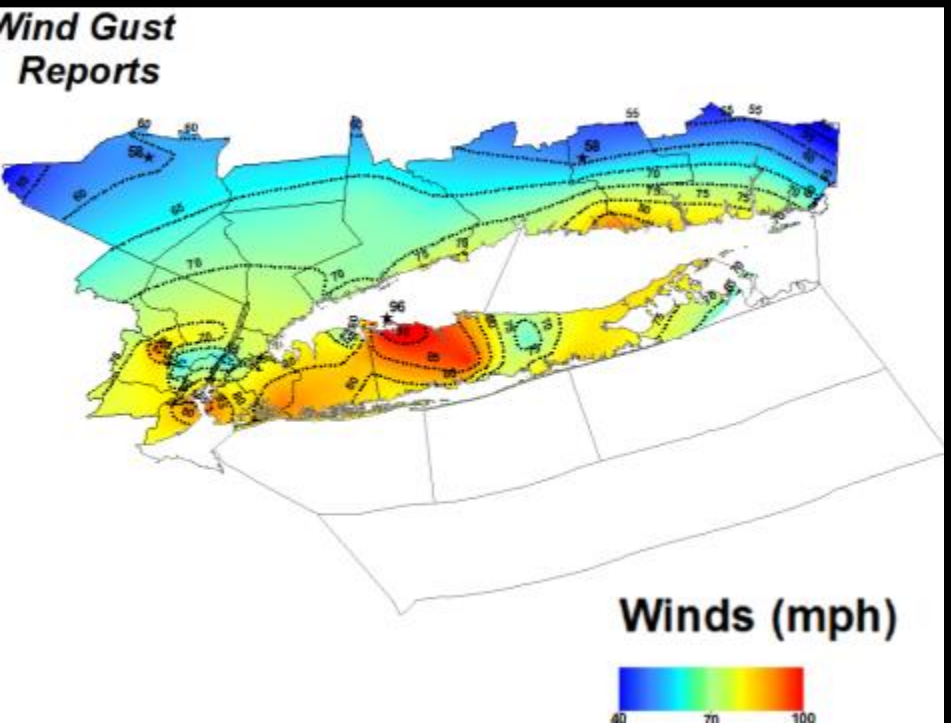
1. Simulation Modeling 101
2. General WI River model framework and status update
3. WI River SWAT model setup
4. SWAT model details (Dave)

A computer simulation model is a set of equations and/or algorithms that describe the behavior of an interconnected system


NAM Atmospheric Column Maximum Composite Radar Reflectivity [dbZ]
00Z10JUL2012+000Hrs
55N
50N
45N
40N
35N
30N
25N
20N
15N
130W
125W
120W
115W
110W
105W
100W
95W
90W
85W
80W
75W
70W
65W
40
35
30
25
20
15
10
5
0
-5
-10
-15

2 AM Fri
2 AM Thu
2 AM Tue
2 AM Wed
5 AM Sun
2 AM Mon
Bermuda
Hurricane Sandy
Current Information:
Center Location 31.9 N 73.3 W
Max Sustained Wind 75 mph
Forecast Positions:
Tropical Cyclone
Sustained Winds:

White Plains
72
7:05pm
Caldwell
70
6:14pm
Teaneck
76
7:31pm
Bridgeport
76
5:49pm
Madison
85
5:20pm
Groton
75
3:35pm
Great Gull Island
85
4:35pm
Eatons Neck
96 (71 FT)
87 (10 M)
6:55pm
LGA
74
6:55pm
Clifton
80
9:30pm
Patchogue
77
7:01pm
Farmingdale
79
7:23pm
East Moriches
81
6:00pm
Syosset
82
7:03pm
Newark
78
7:51pm
NYC
62
3:13pm
Islip
90
6:26pm
JFK
85
8:02pm
NOAA
Maximum Wind Gusts
Post Tropical Cyclone Sandy
October 29, 2012
All Speeds in MPH Measured at 10 M


Wind Gust Reports
Winds (mph)

pin.primate.wisc.edu

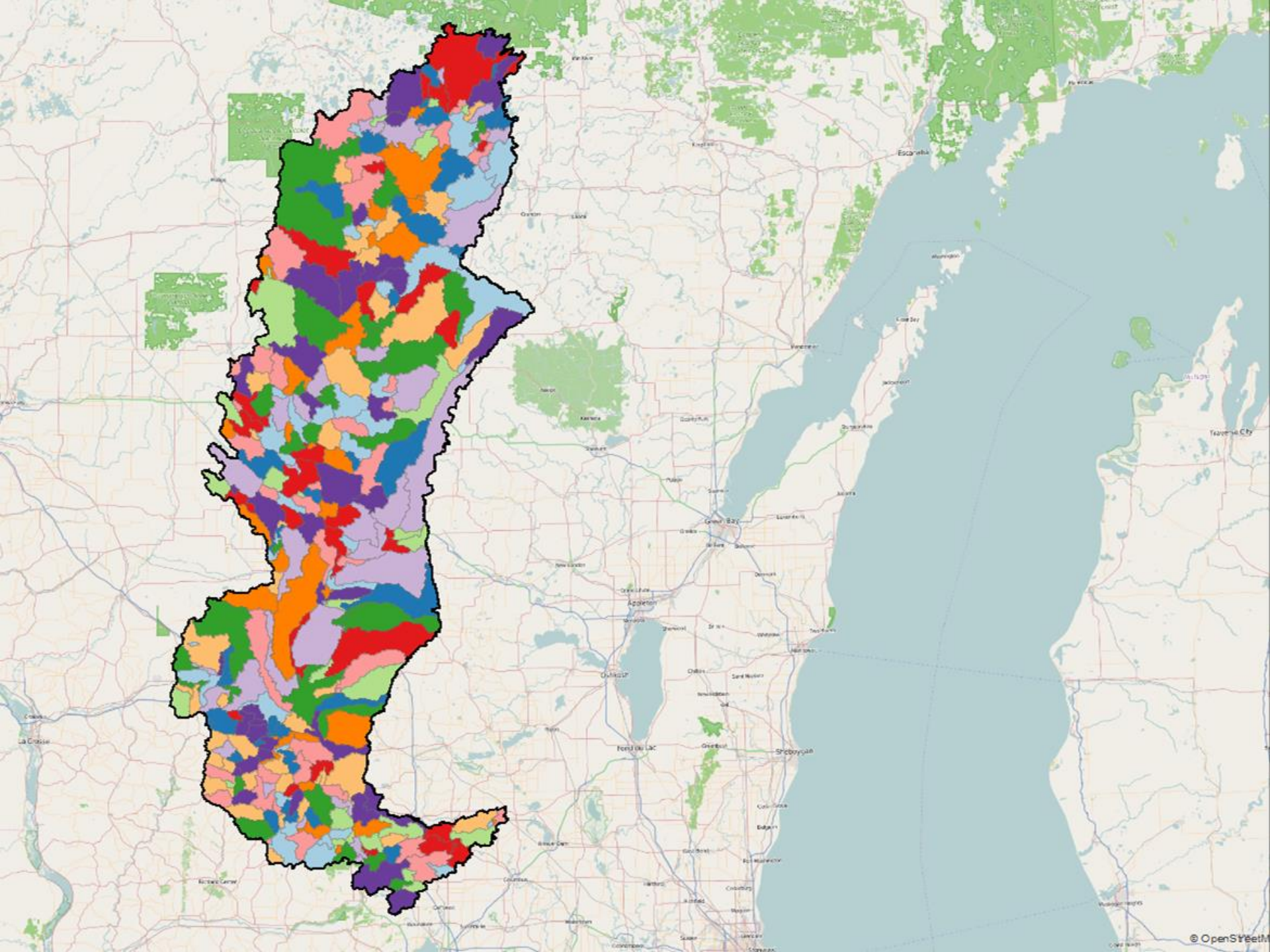
acssm.edu/

Tributary Prediction targets

Average:

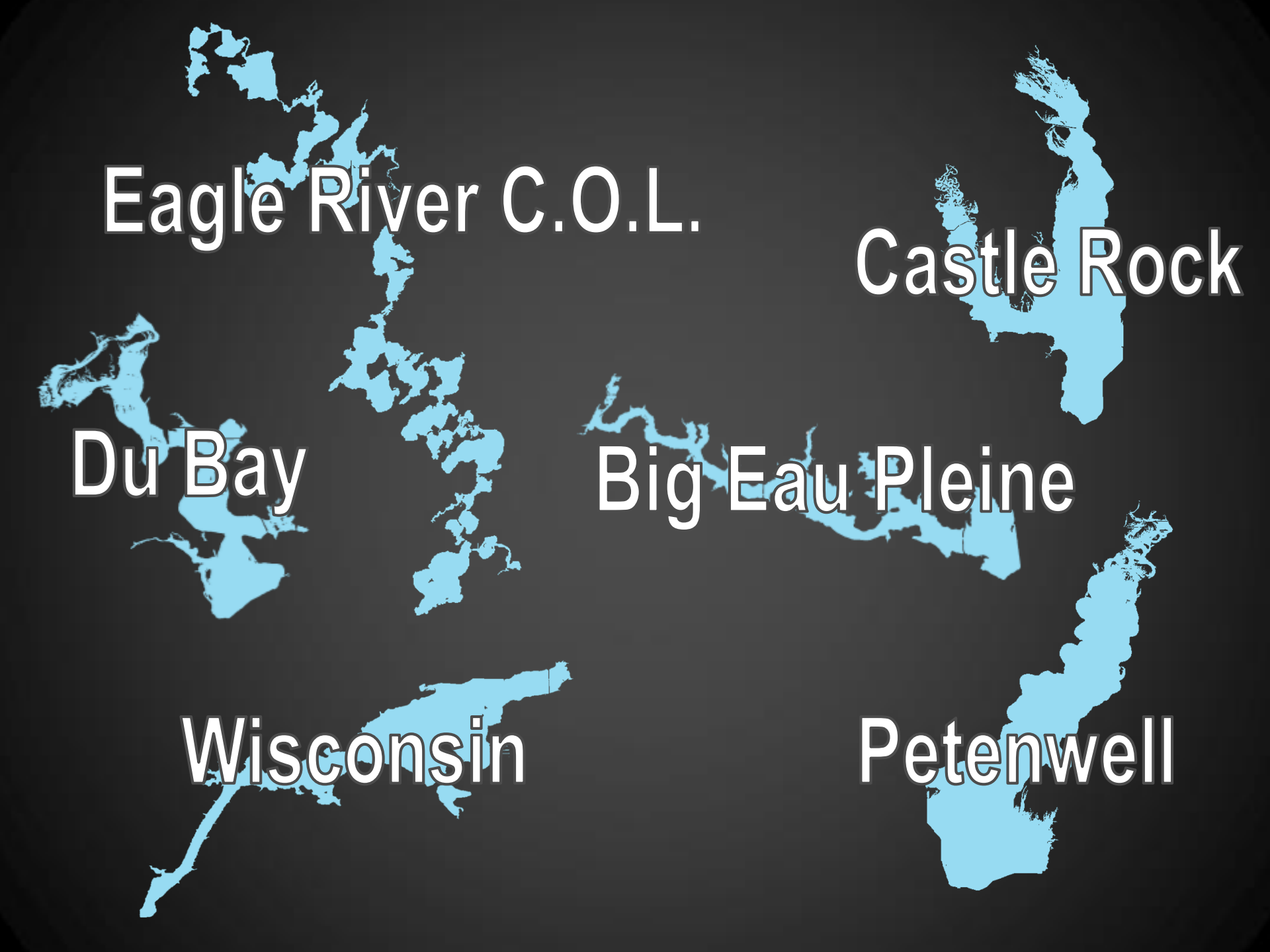
1. daily **streamflow**
2. monthly **sediment** load
3. monthly **phosphorus** load

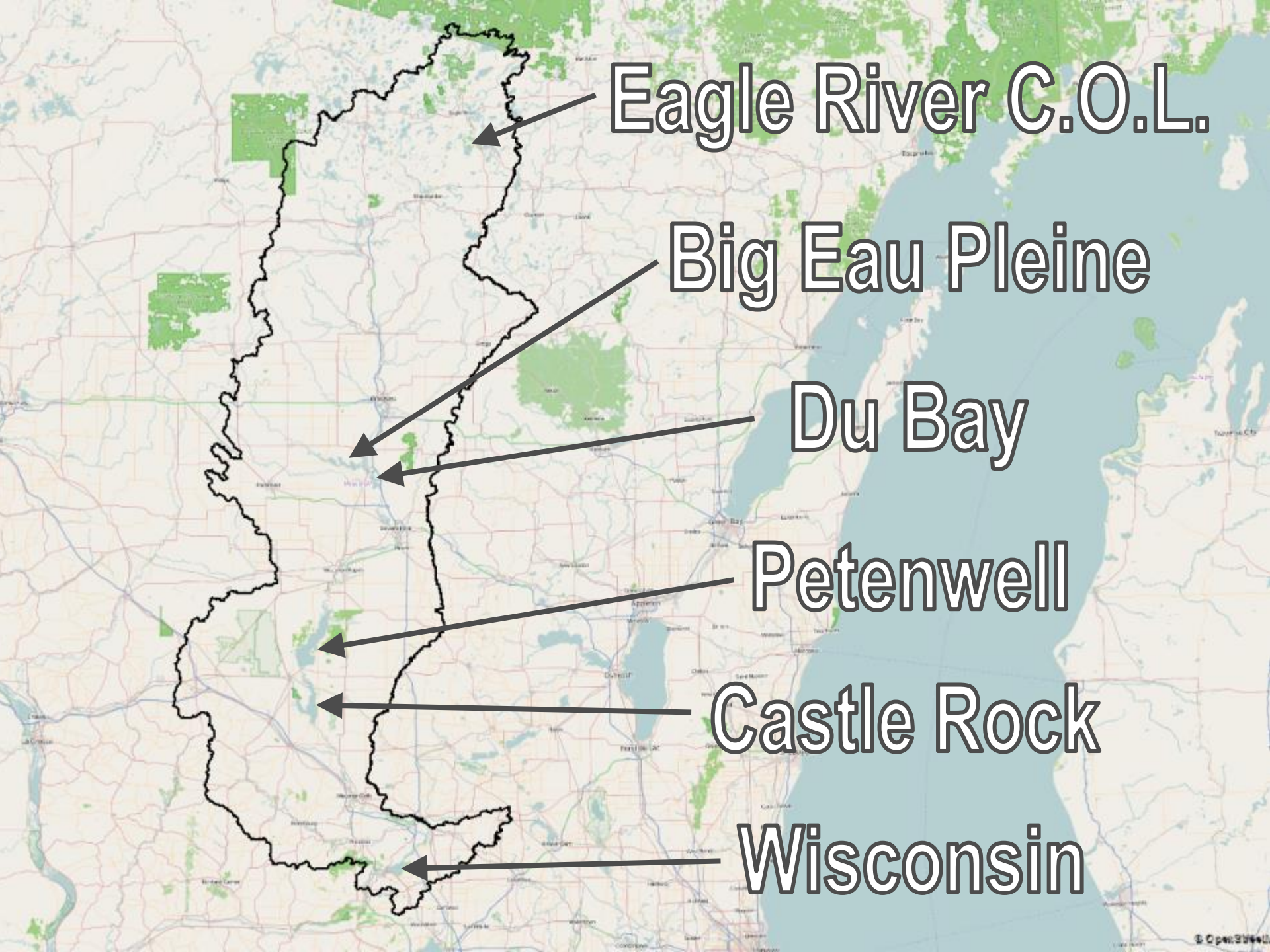
...at 337 locations over a period of 12 years.


Escanaba
Traverse City
Green Bay
Appleton
Oshkosh
Fond du Lac
Sheboygan
La Crosse
© OpenStreetMap

Reservoir response

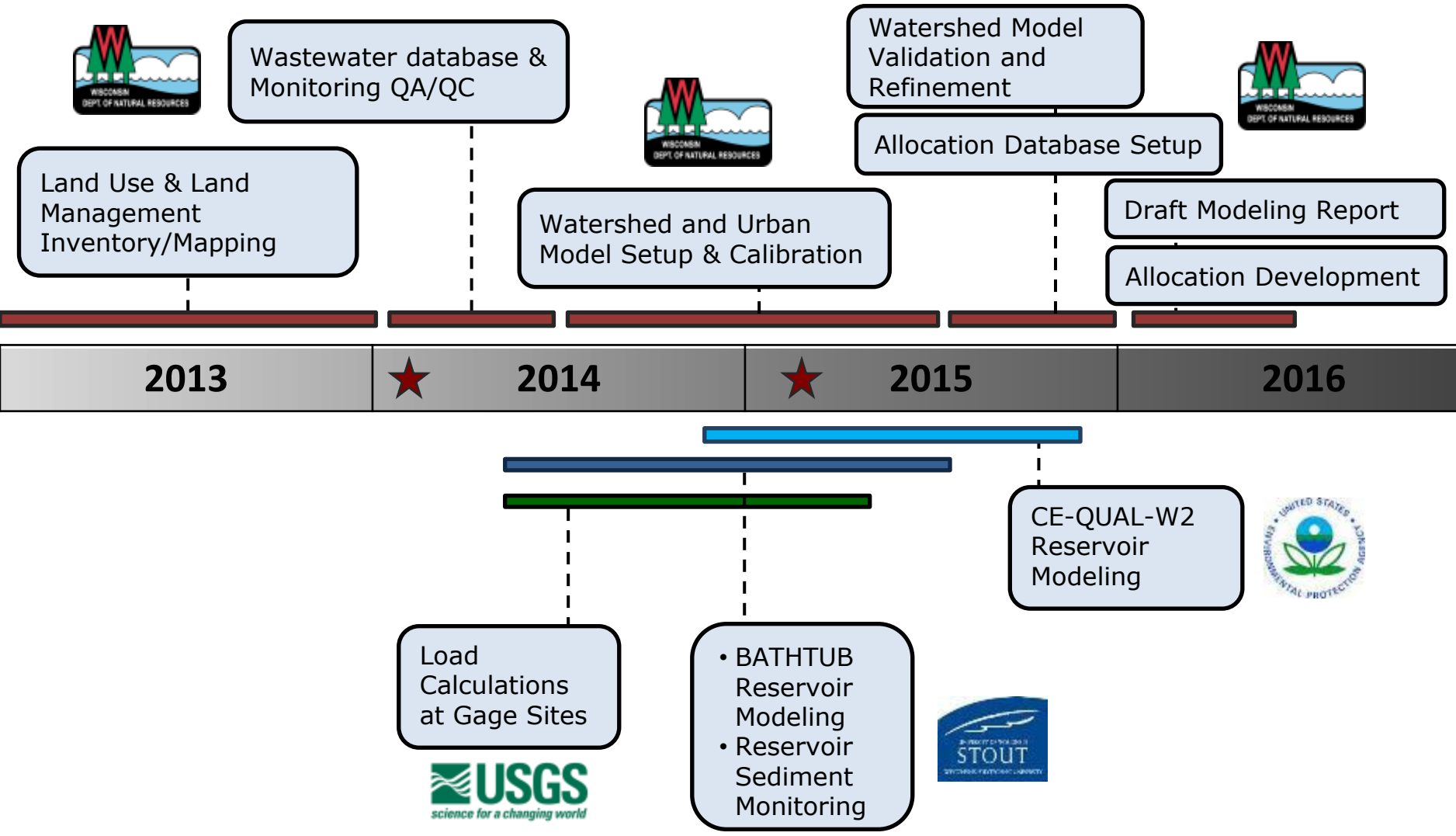
- Nutrient dynamics
  - Variability in time and space
  - Chlorophyll response to nutrients
- Reduction of upstream nutrients to meet water quality standards
- Six de-coupled reservoir models


Eagle River C.O.L.
Castle Rock
Du Bay
Big Eau Pleine
Wisconsin
Petenwell

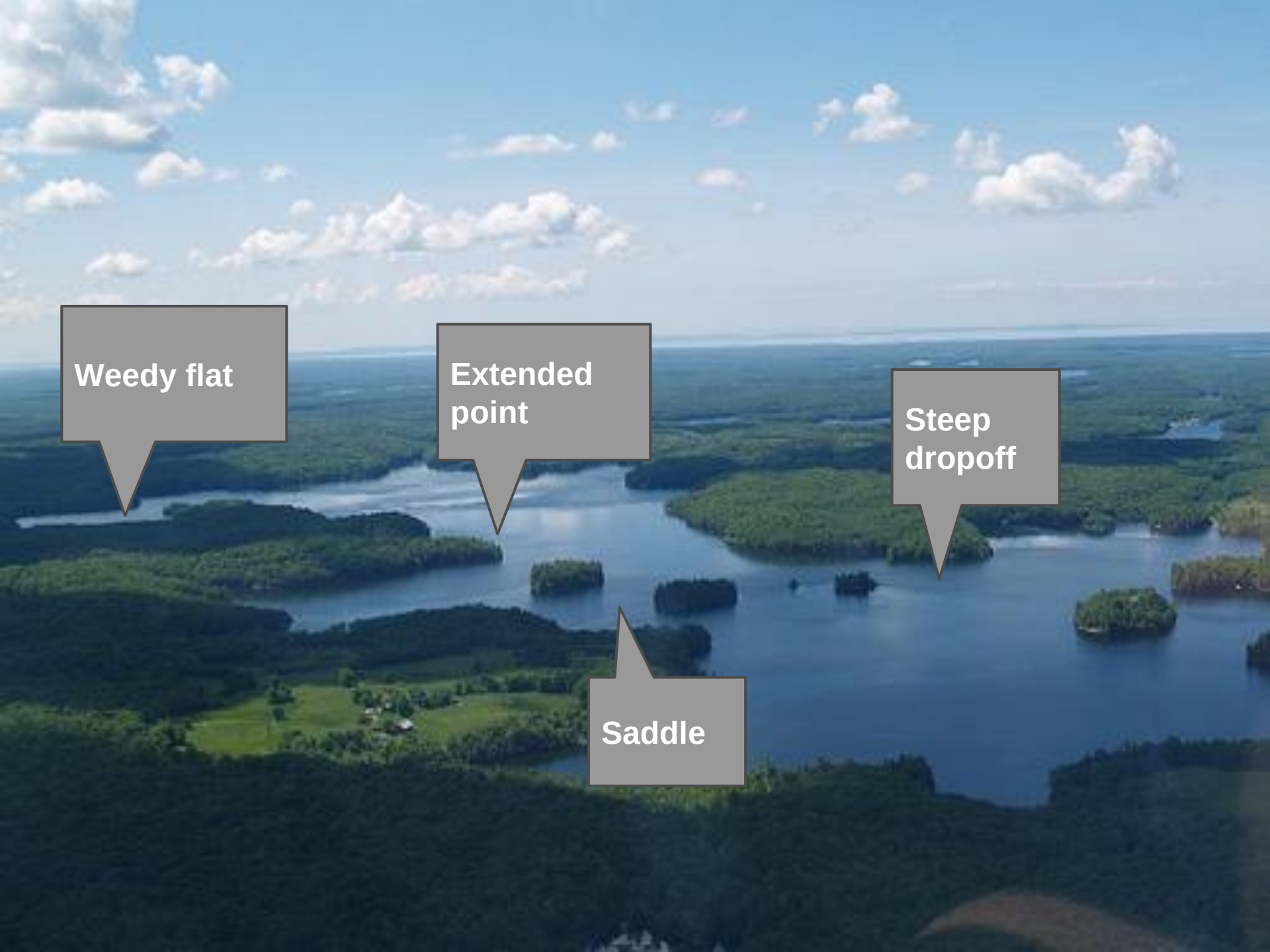

Eagle River C.O.L.
Big Eau Pleine
Du Bay
Petenwell
Castle Rock
Wisconsin

WRB Water Quality Improvement Project

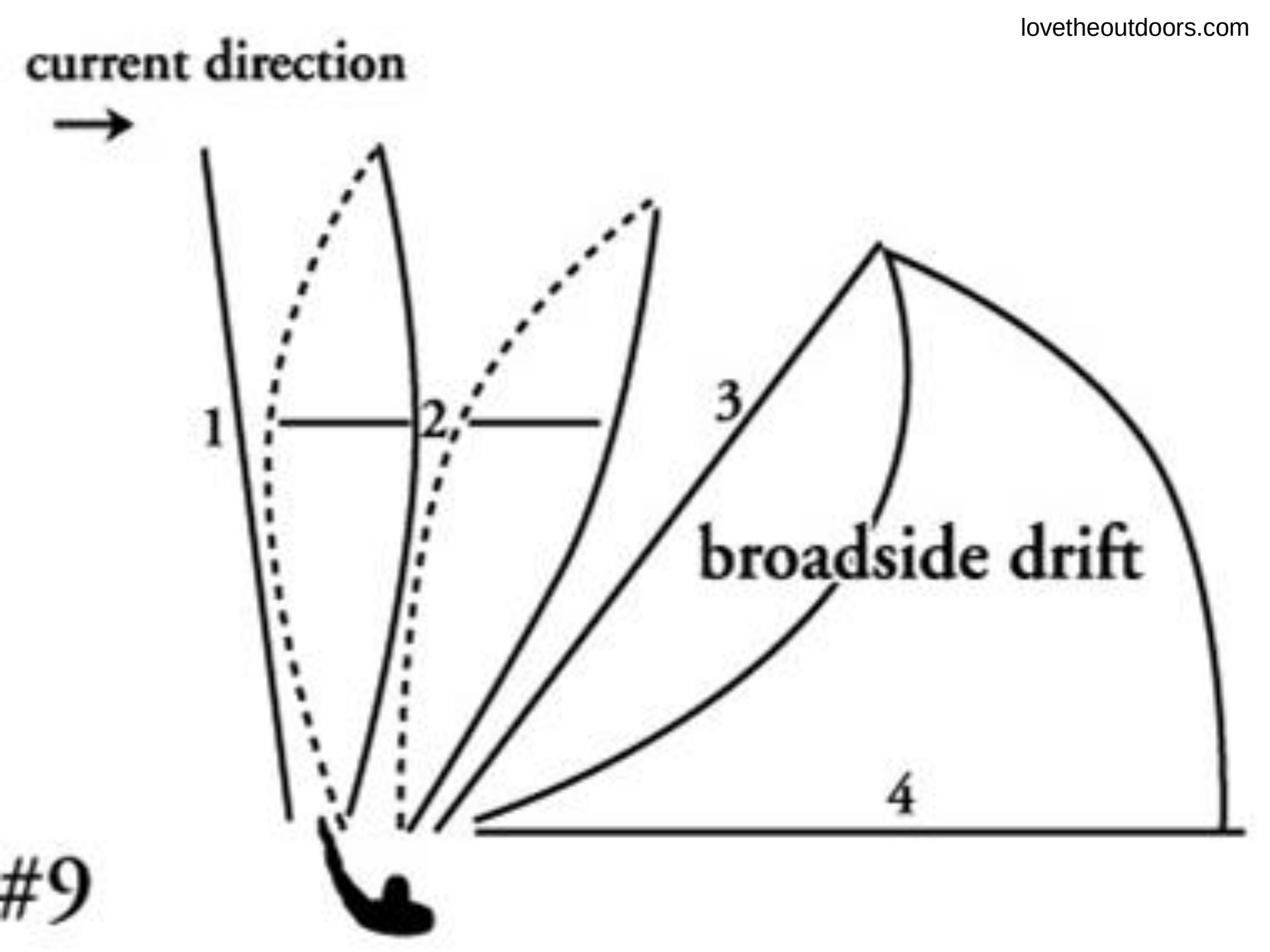
Detailed Technical Timeline



parameterization
Rapala SUPER SHAD RAP
COVER THE WATER
Rapala MAGNUM
MAGNUM


Weedy flat
Extended point
Steep dropoff
Saddle

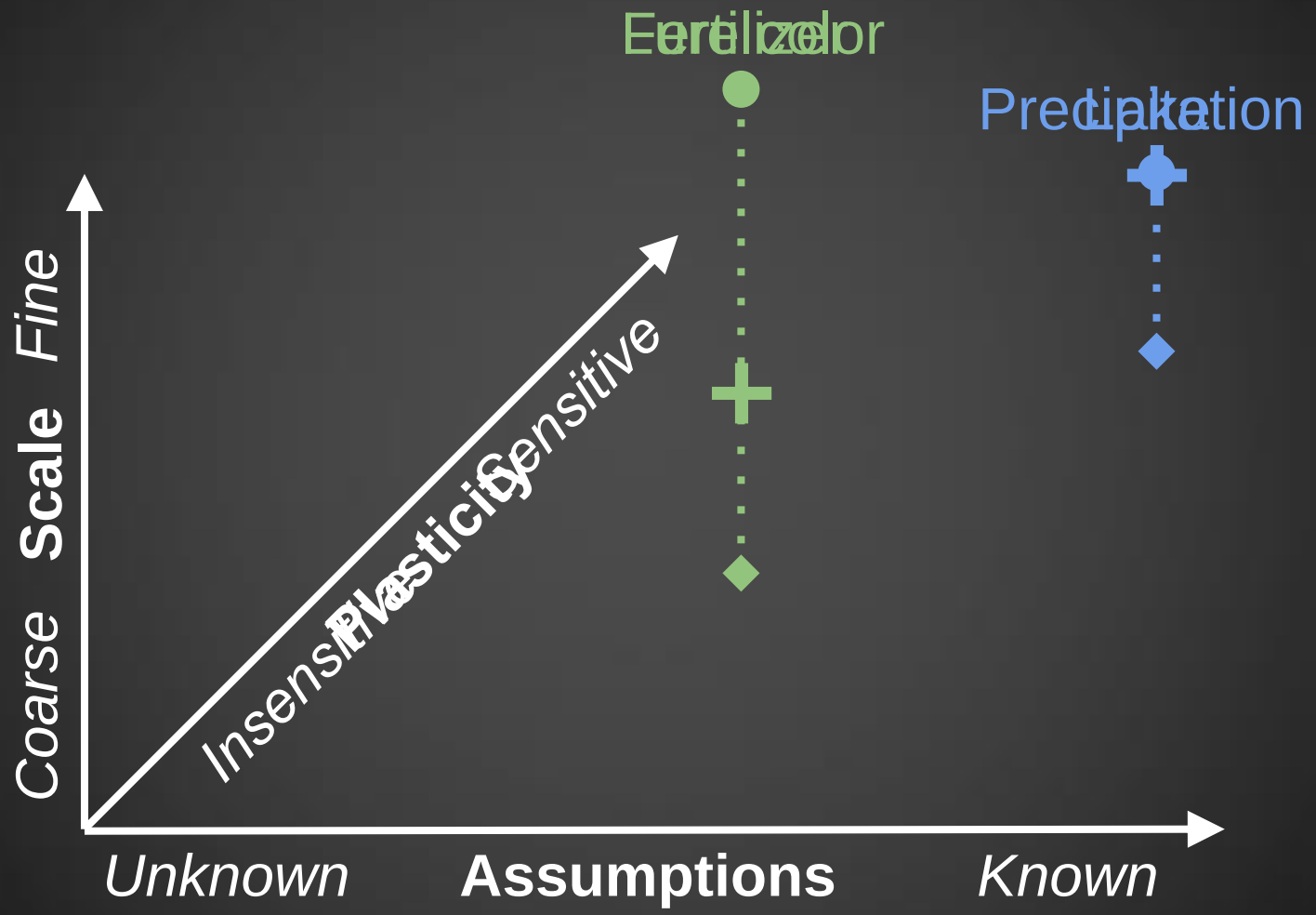
lovetheoutdoors.com



#9

lag
CRP
precipitation
landcover
crop
soils
pasture
humidity
wastewater
springs
slope
geology
groundwater
routing
drainage
impoundments
scale
tiles
livestock
depth
bedrock
location
solar
tillage
erodibility
ditching
roughness
wind
seasonality
agriculture
climate
urban
timing
fertilizer
velocity
settling
resuspension

tagxedo.com


Fertilizer
Precipitation
Coarse
Scale
Fine
Insensitive
Plasticity
Sensitive
Unknown
Assumptions
Known

dlt.ncssm.edu/

GitHub

github.com/dnrwaterqualitymodeling

Part 2 - Overview

Technological Innovations

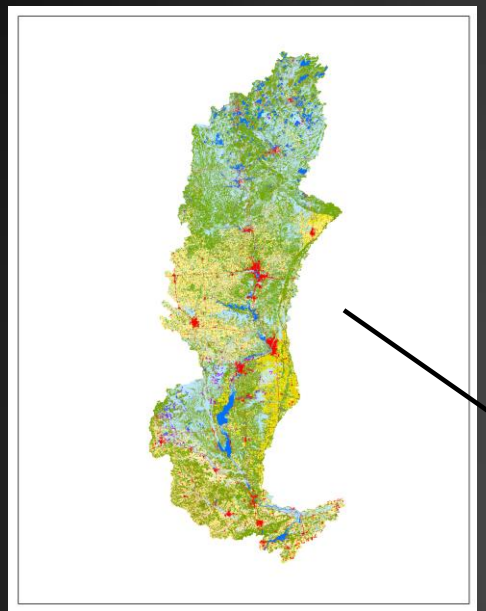
- Remote sensing (land cover and management)
- gSSURGO (coarse-scale analysis, use of statistical methods for aggregating soils)
- Cloud computing

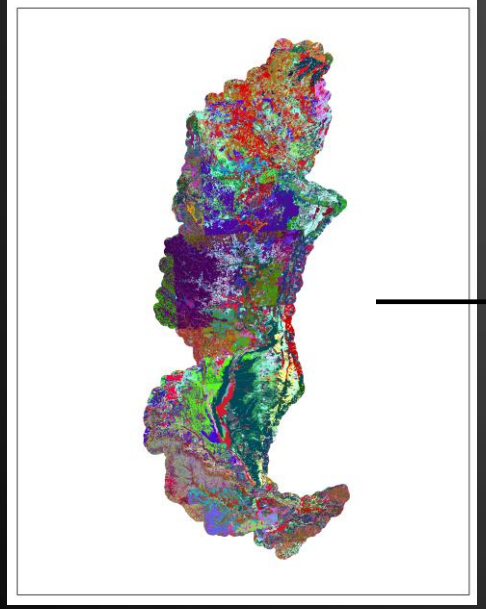
Calibration

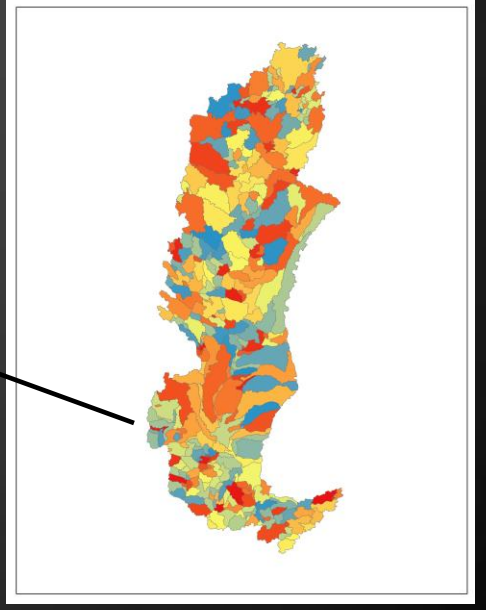
- Overview
- Sensitivity Analysis

Soil & Water Assessment Tool

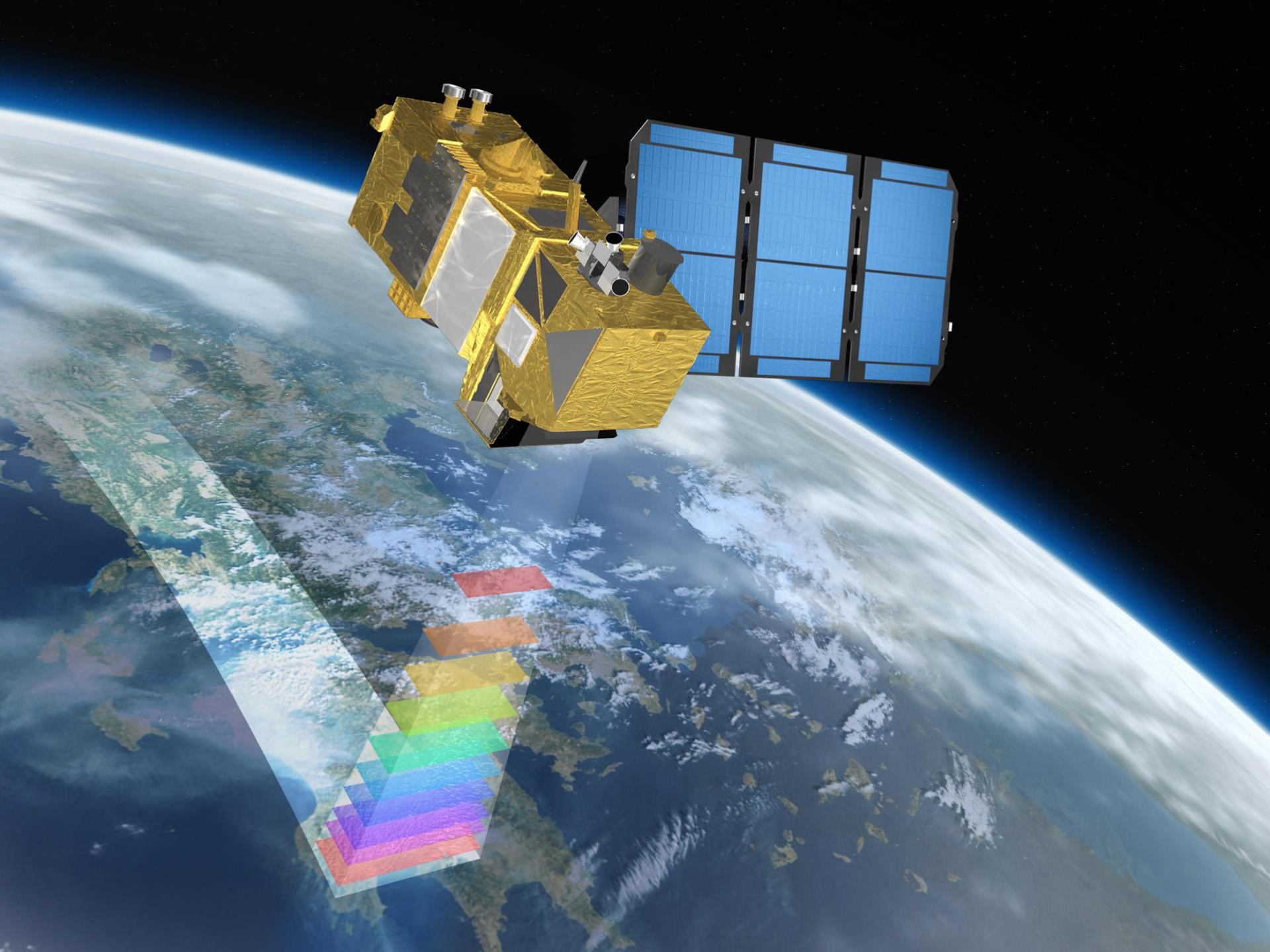
Model Configuration

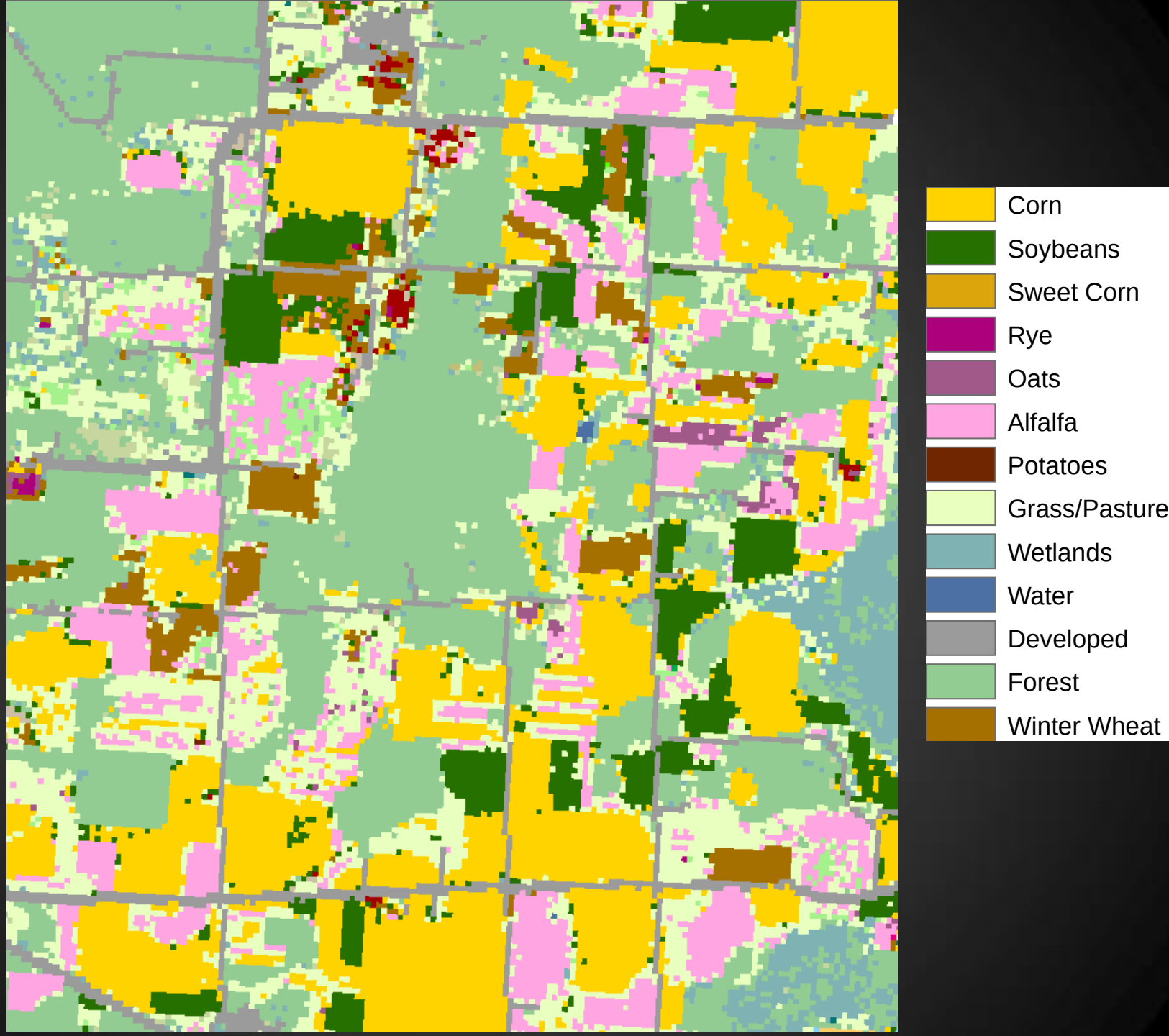


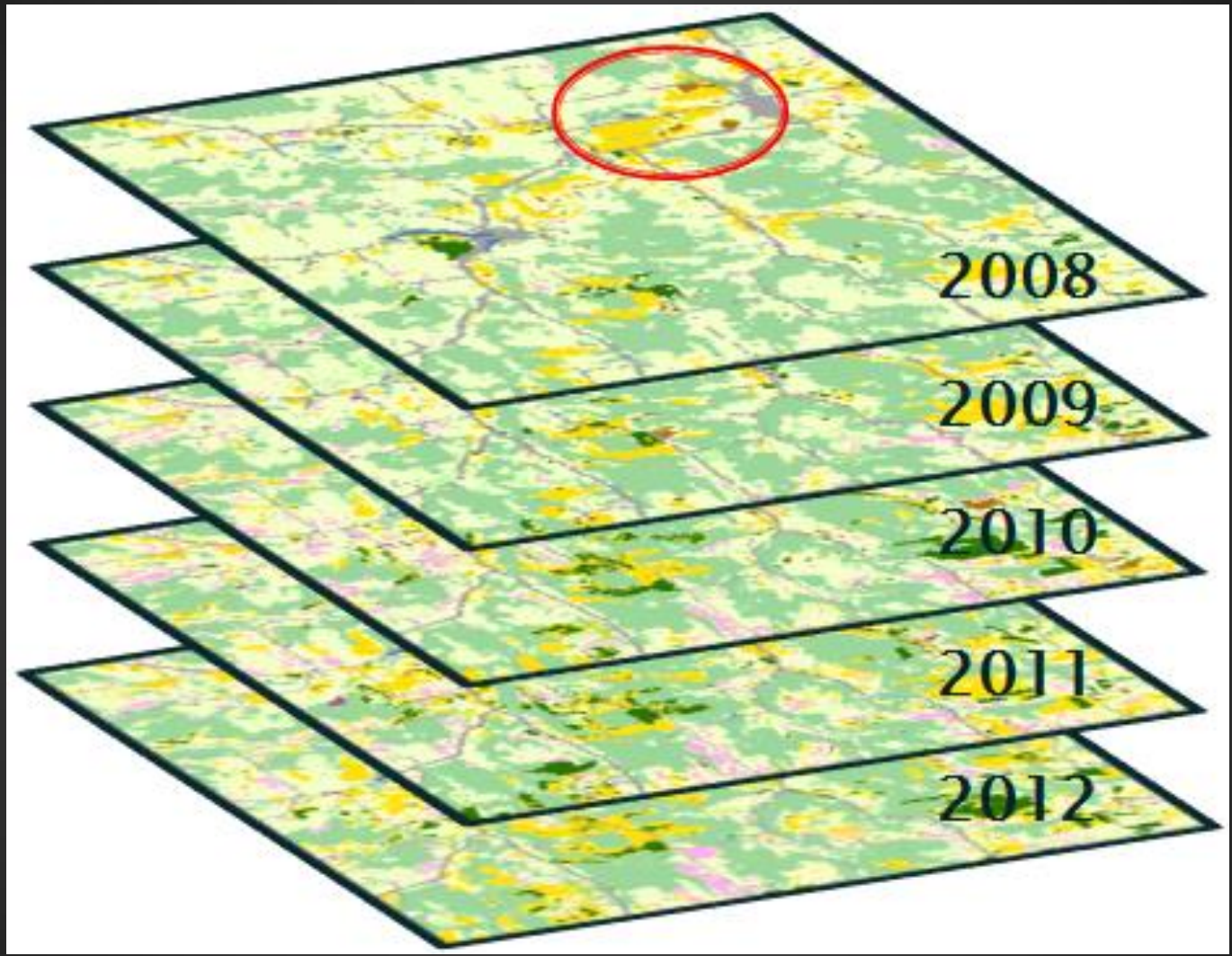


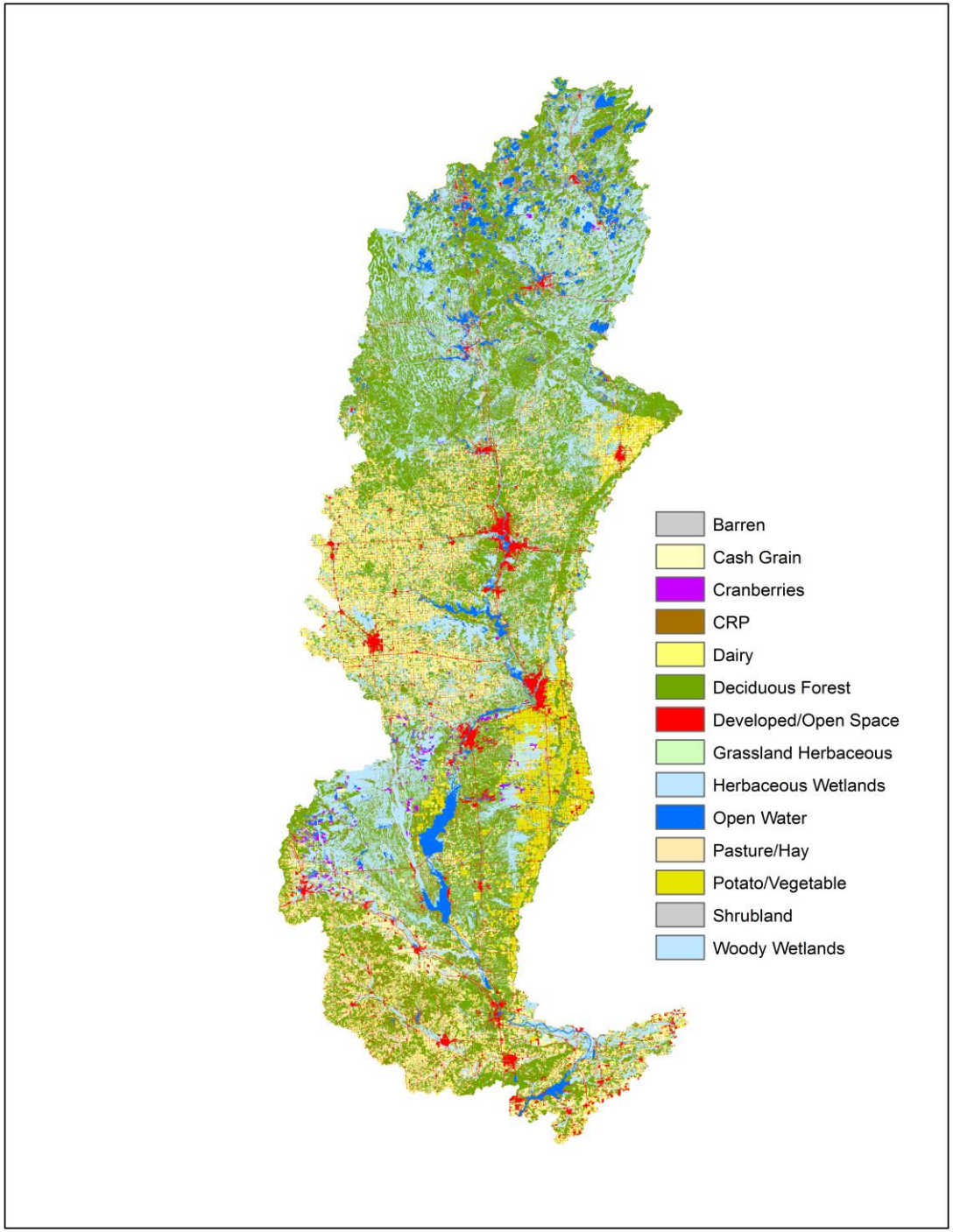


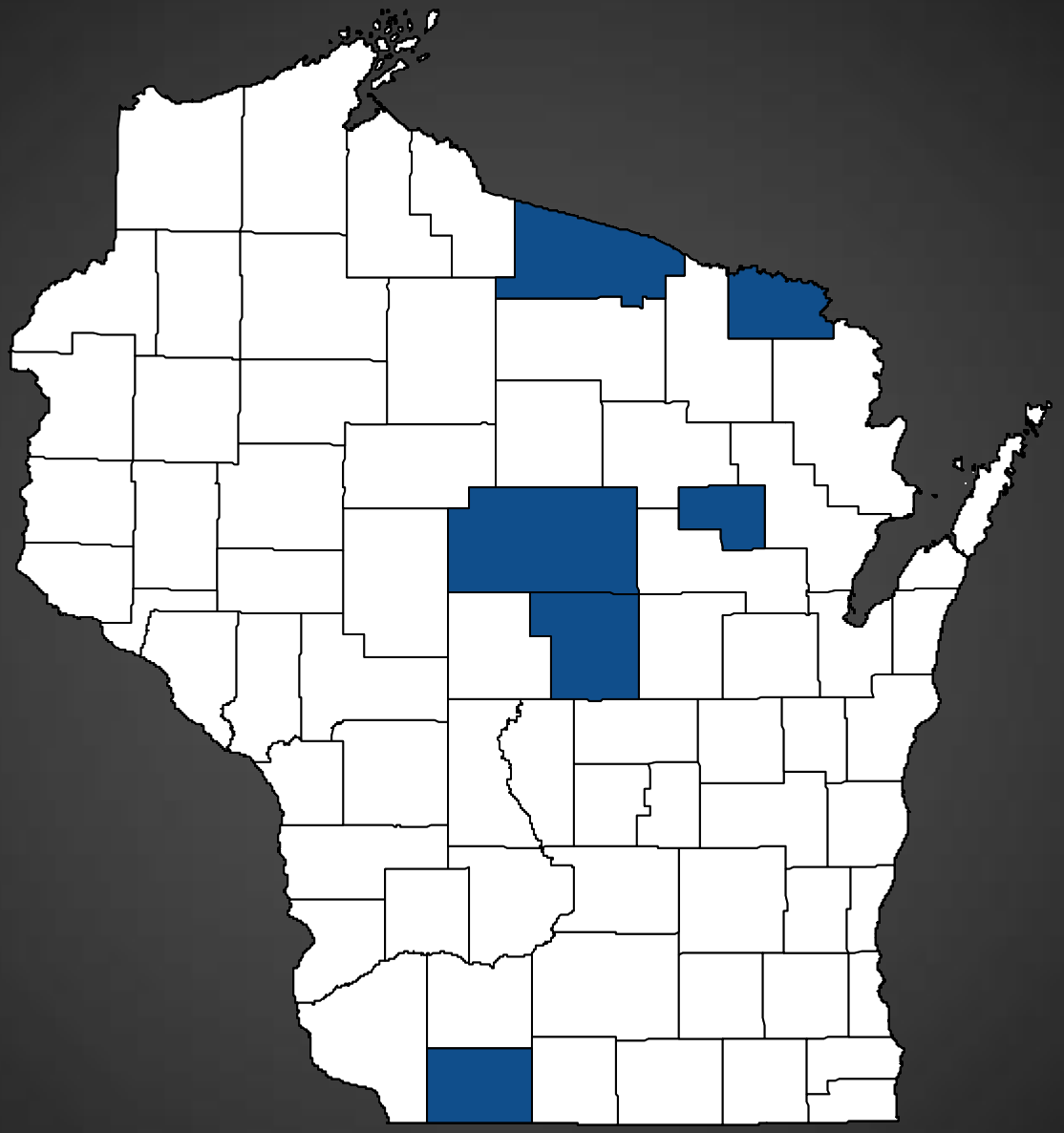
Soil & Water Assessment Tool

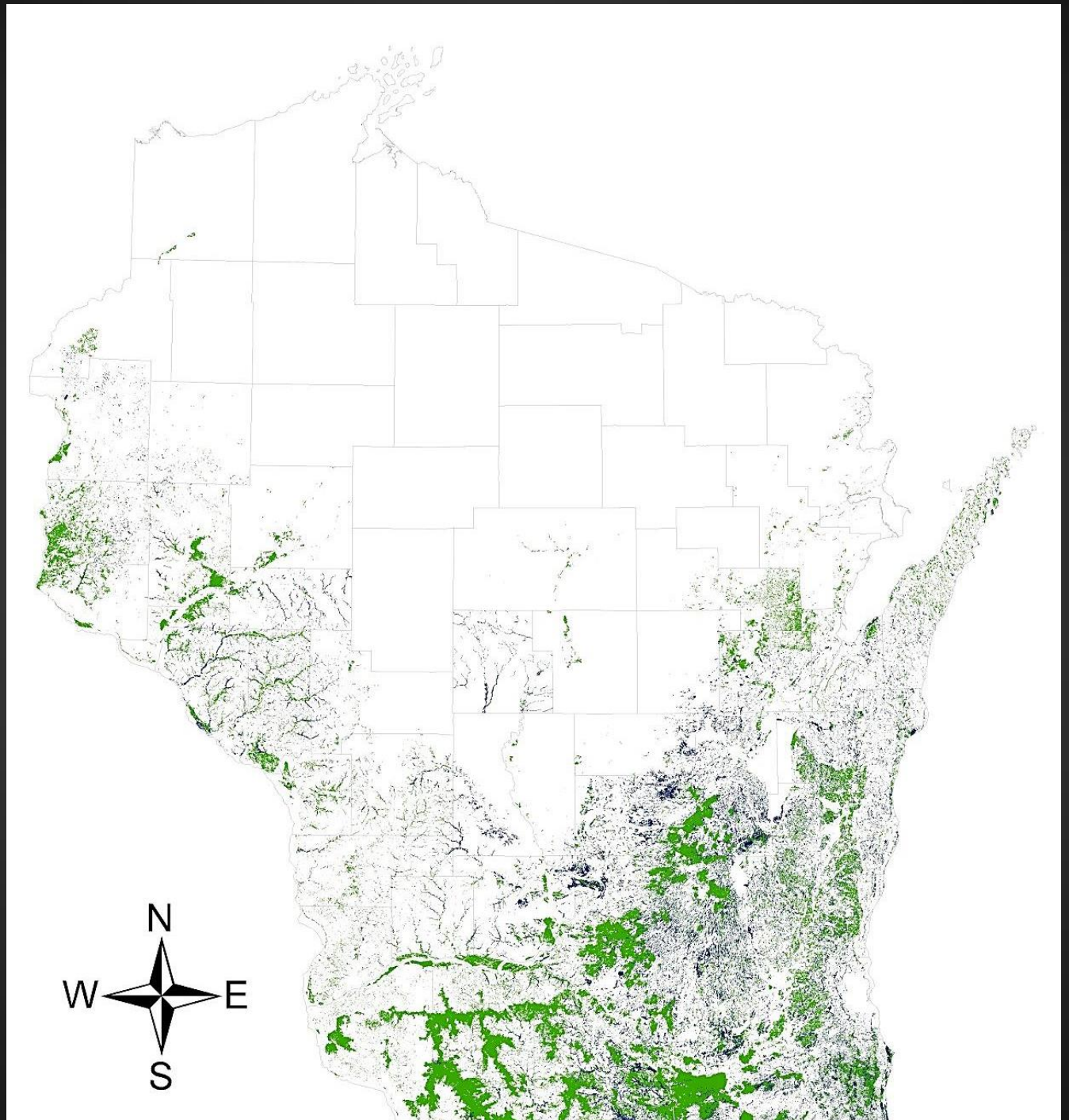


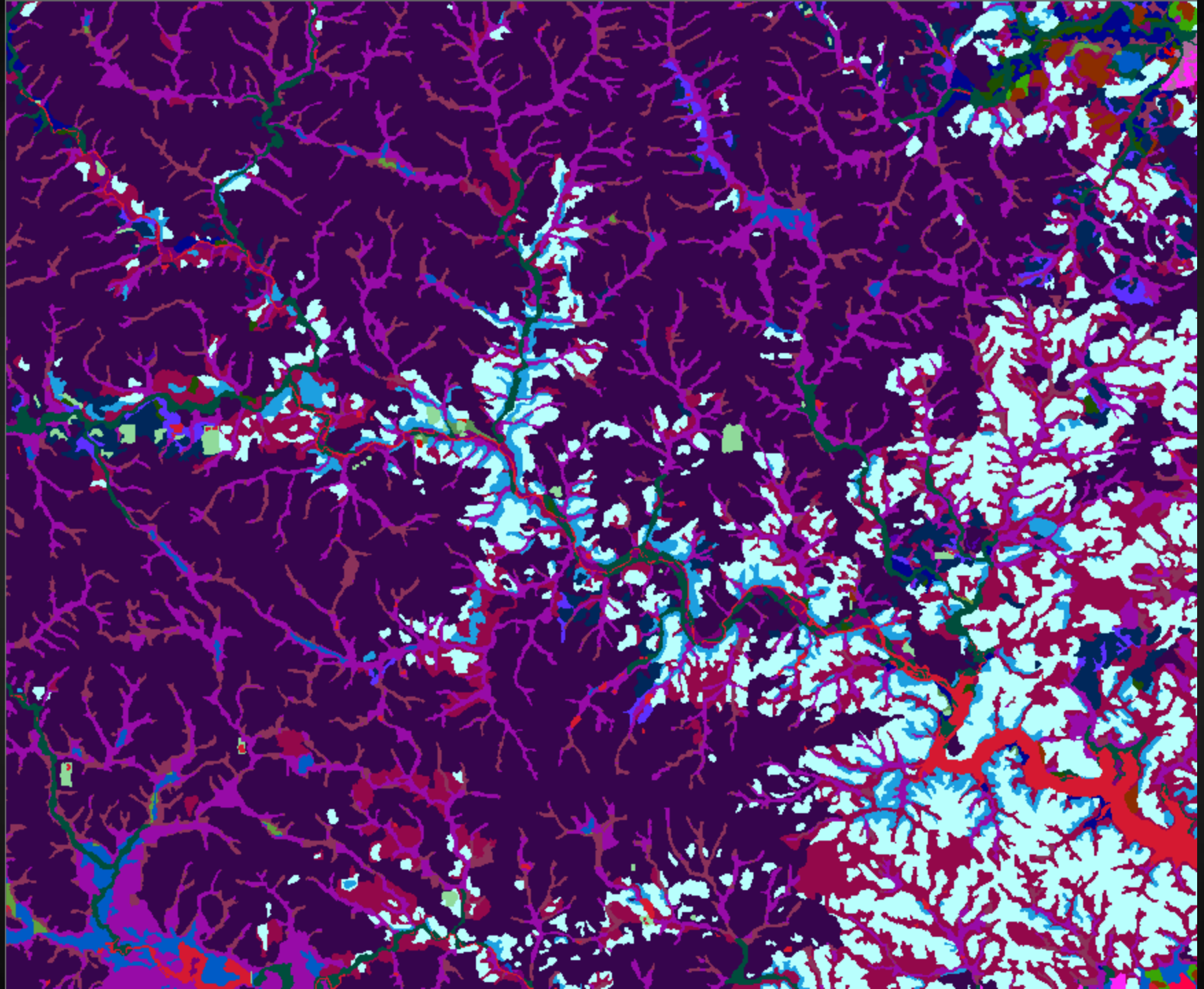

Corn
Soybeans
Sweet Corn
Rye
Oats
Alfalfa
Potatoes
Grass/Pasture
Wetlands
Water
Developed
Forest
Winter Wheat

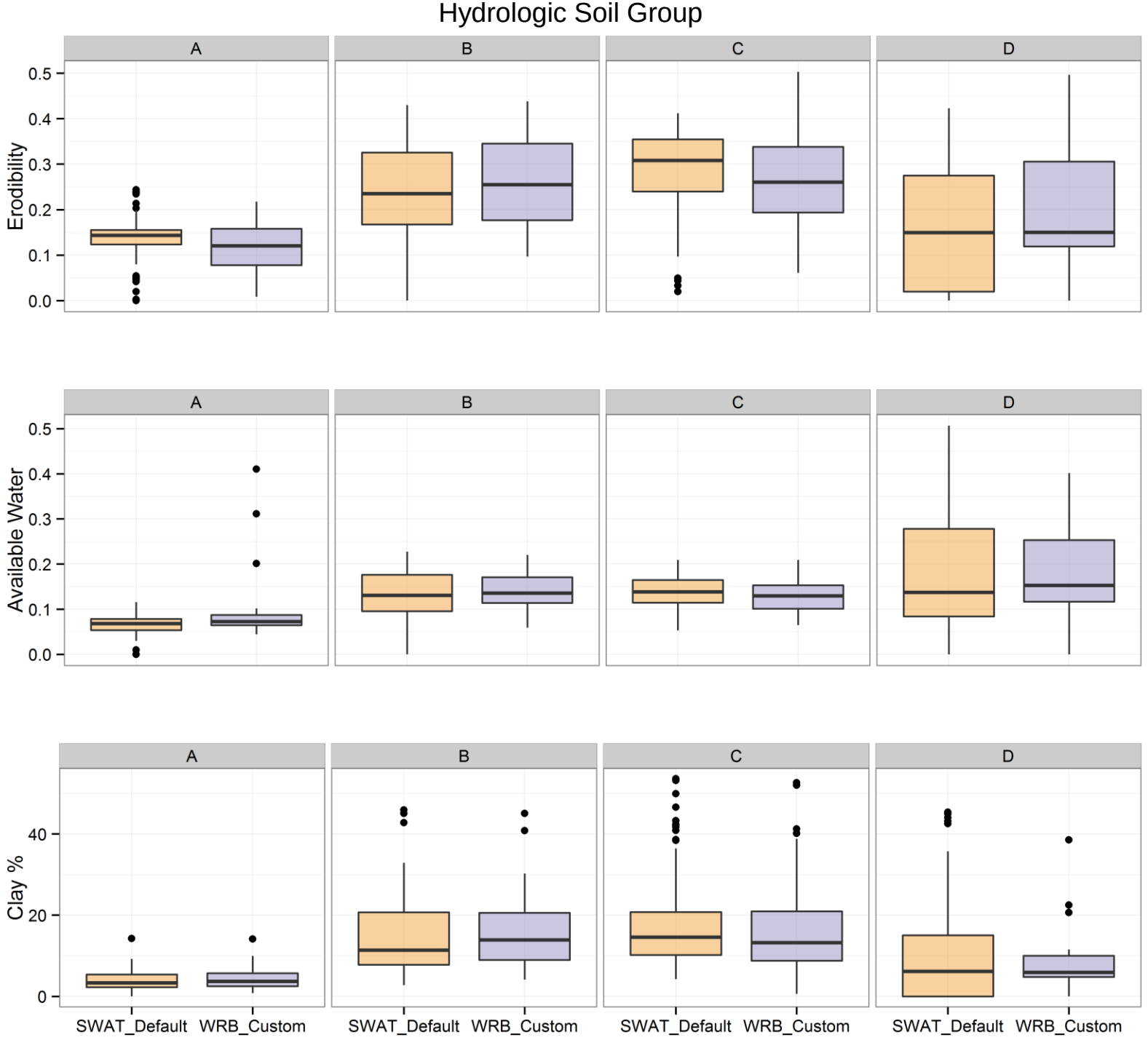

2008
2009
2010
2011
2012


Barren
Cash Grain
Cranberries
CRP
Dairy
Deciduous Forest
Developed/Open Space
Grassland Herbaceous
Herbaceous Wetlands
Open Water
Pasture/Hay
Potato/Vegetable
Shrubland
Woody Wetlands




N
W
E
S



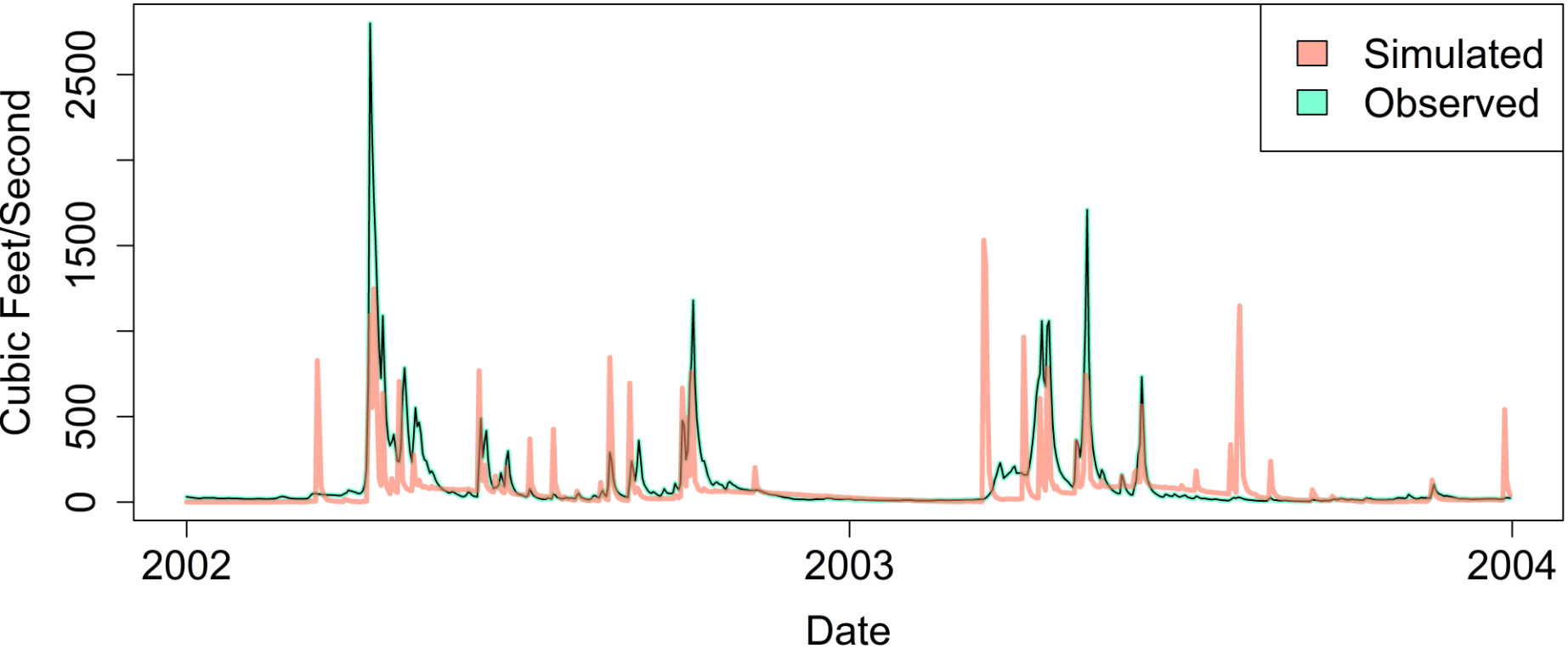

Hydrologic Soil Group
A
B
C
D
Erodibility
0.0
0.1
0.2
0.3
0.4
0.5
Available Water
0.0
0.1
0.2
0.3
0.4
0.5
Clay %
0
20
40
SWAT_Default
WRB_Custom

Calibration

Average:

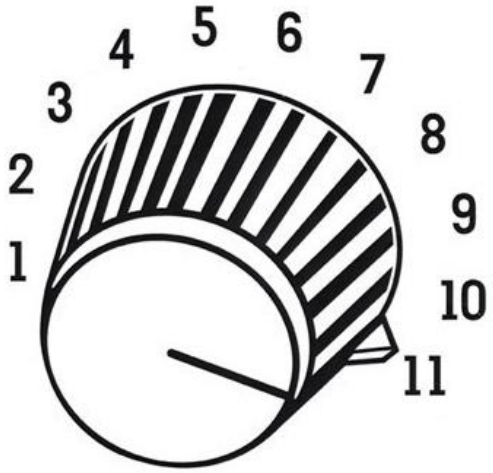
1. daily **streamflow**
2. monthly **sediment** load
3. monthly **phosphorus** load

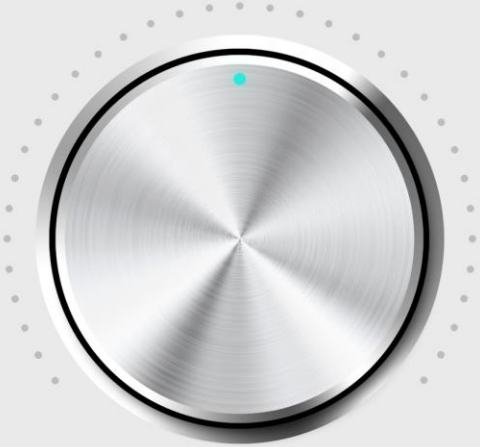
Calibration



Calibration

STREAMFLOW
ADJUSTMENT



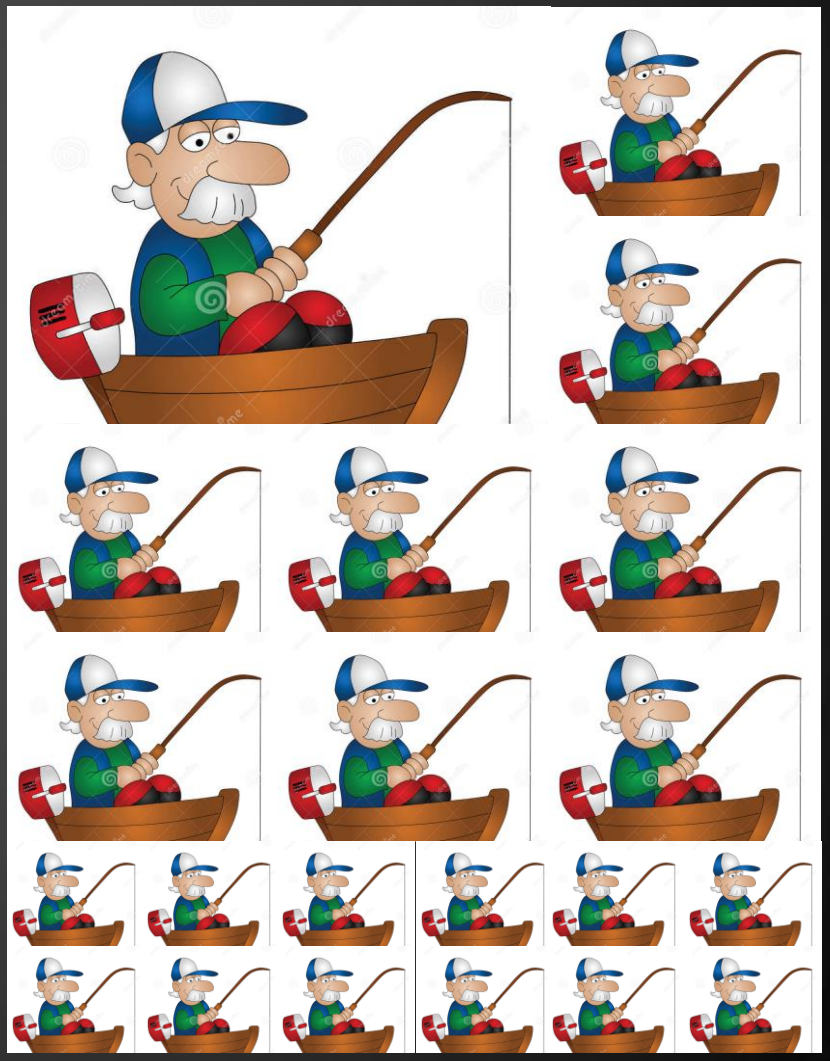


Sensitivity Analysis

Test 100 different lures, same day, same time, same boat, same depth, same fish same lake...

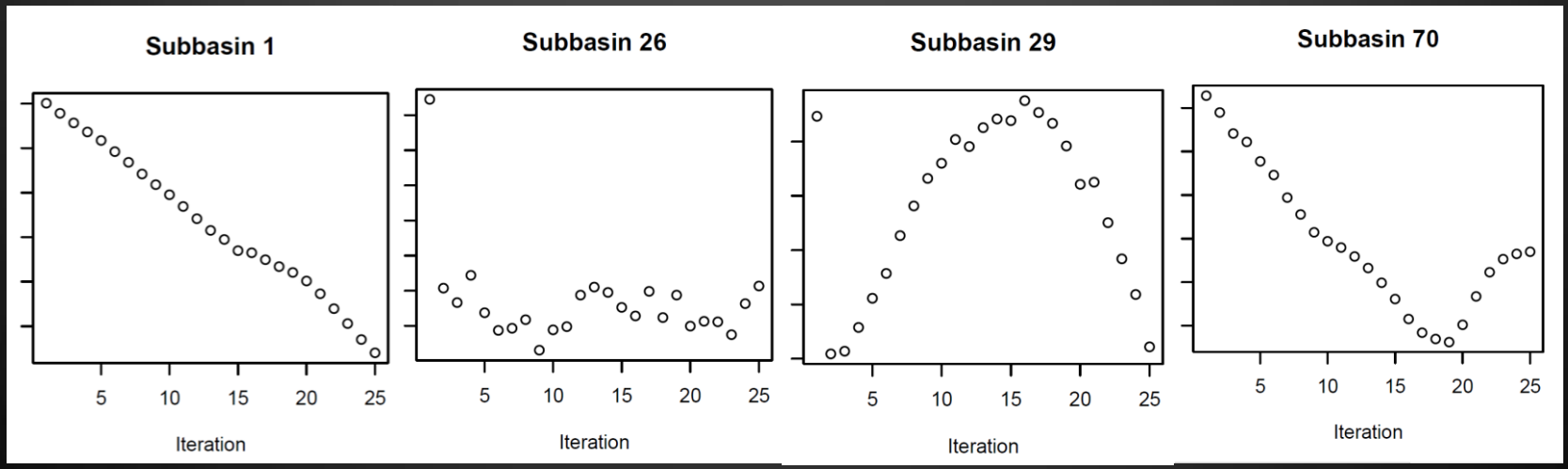
- Does this kind of lure matter and if so, how?

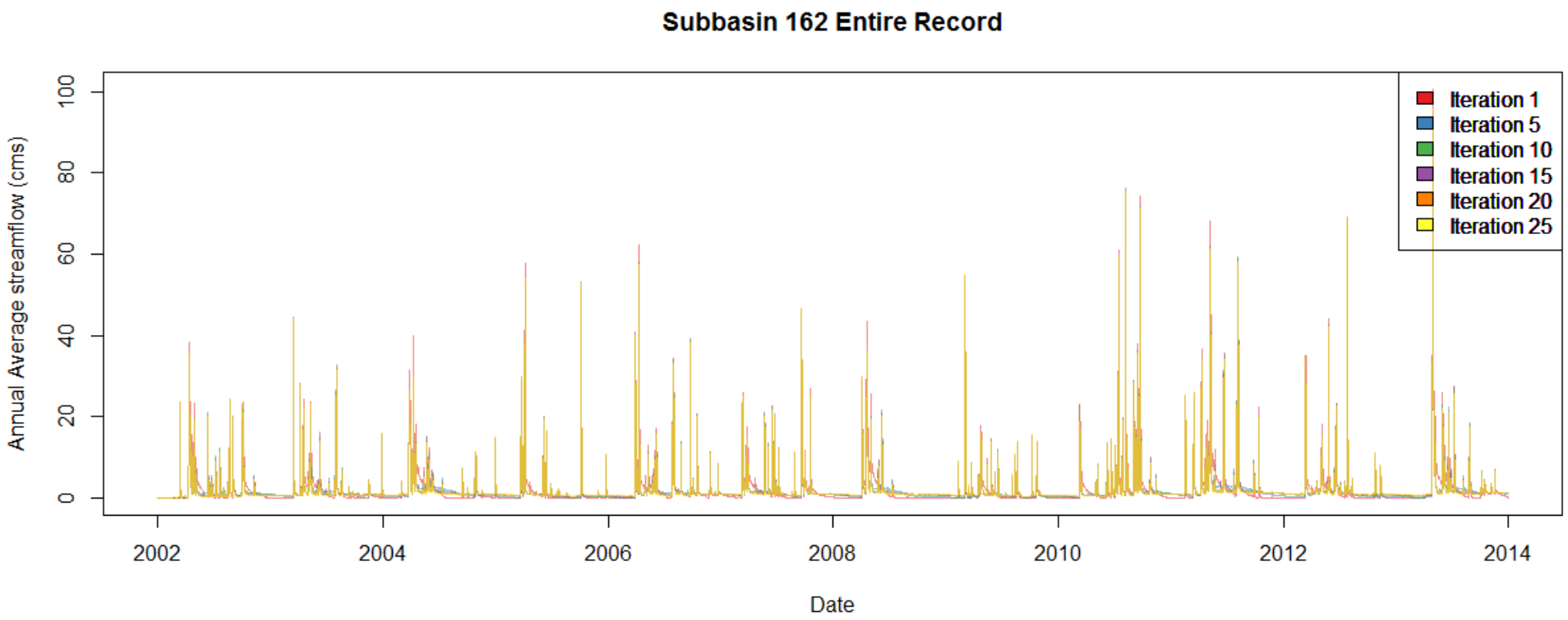
Test 100 different depths, same day, time etc.,

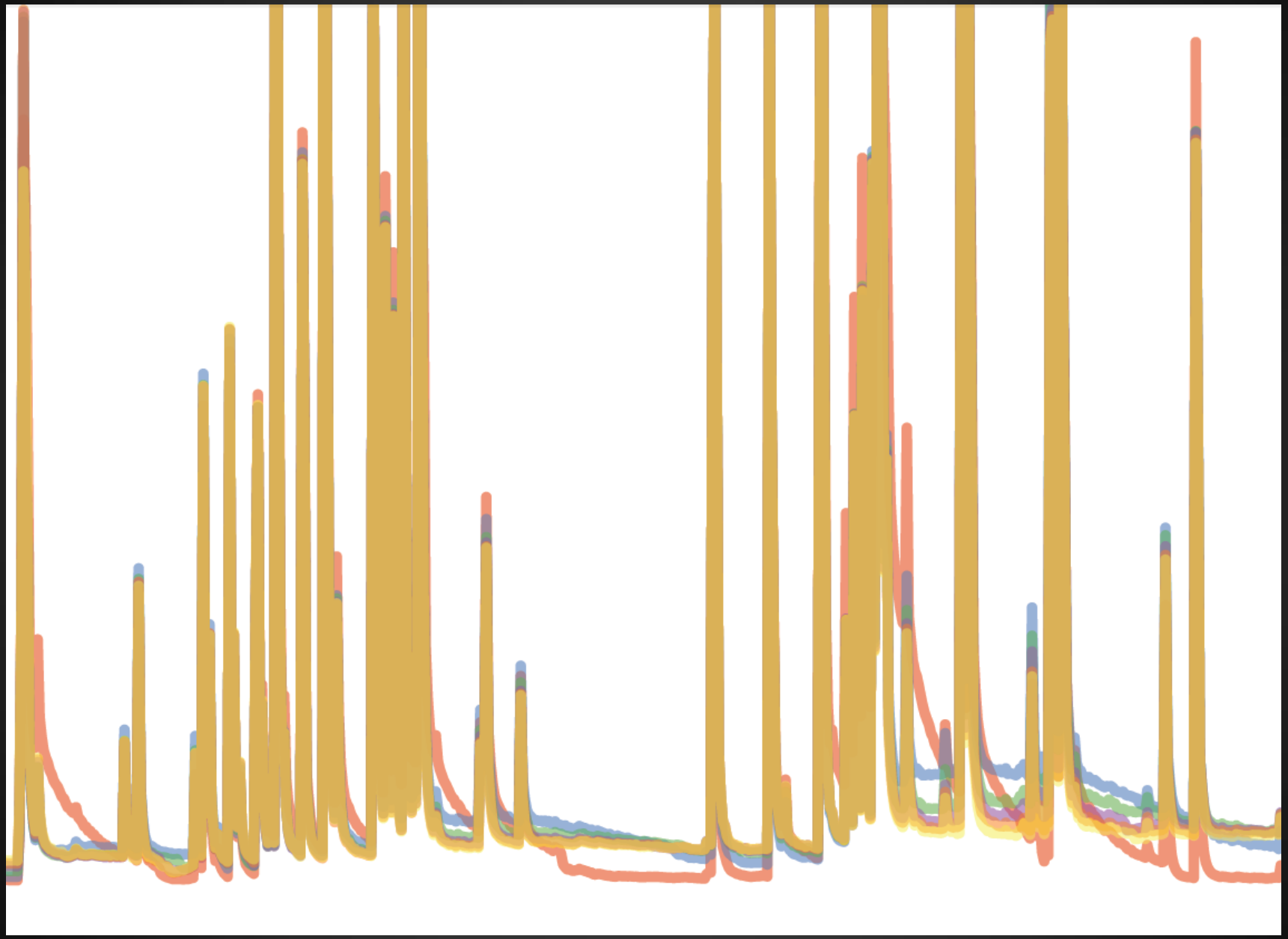


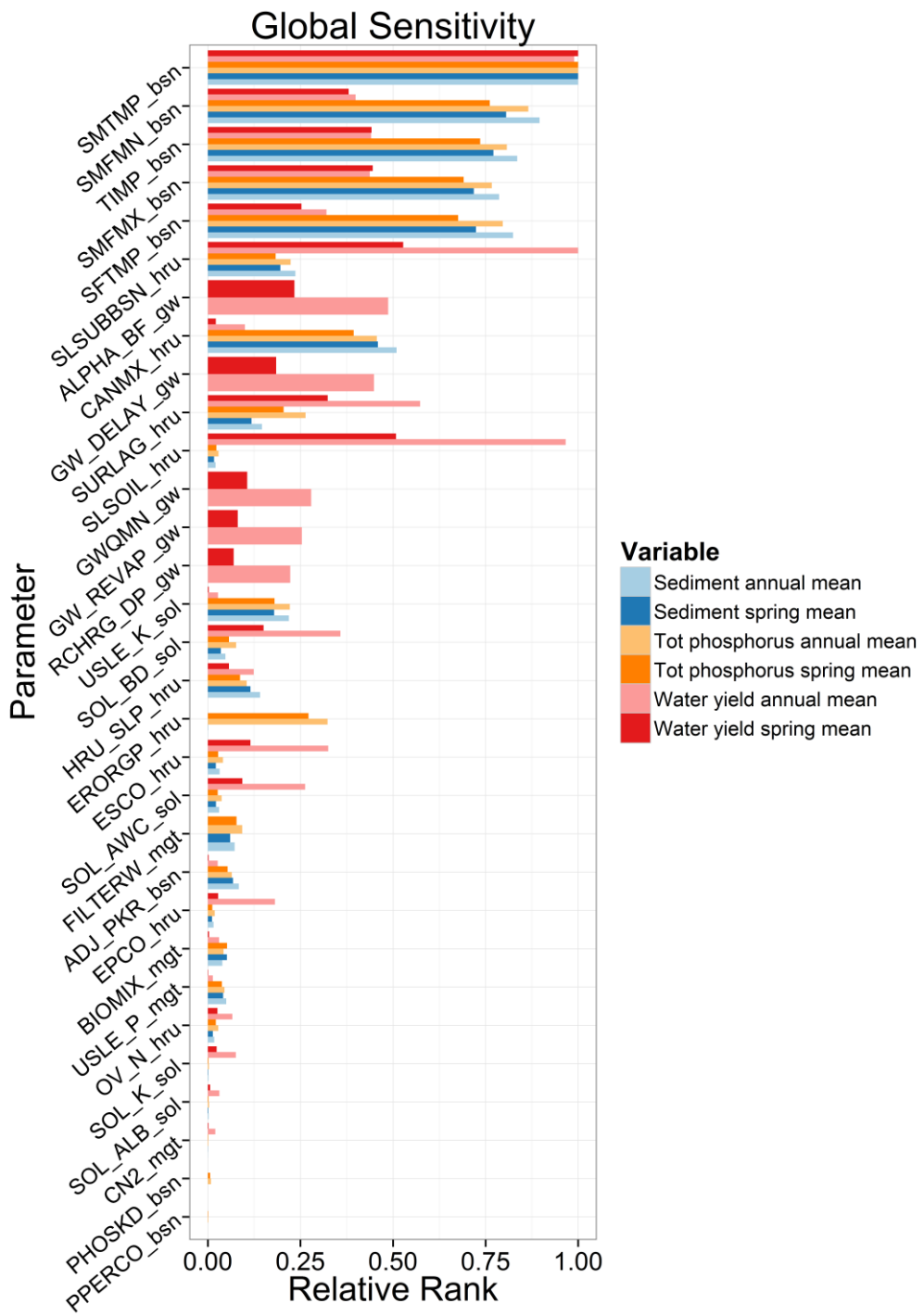
Sensitivity Analysis

- Example: adjusting GW_DELAY
  - Governs how long it takes water leaving the soil to reach the groundwater
  - Does it effect streamflow? How much?
  - Shifts hydrograph? Increases/decreases peak flows?




Subbasin 162 Entire Record
Annual Average streamflow (cms)
0
20
40
60
80
100
2002
2004
2006
2008
2010
2012
2014
Date
Iteration 1
Iteration 5
Iteration 10
Iteration 15
Iteration 20
Iteration 25



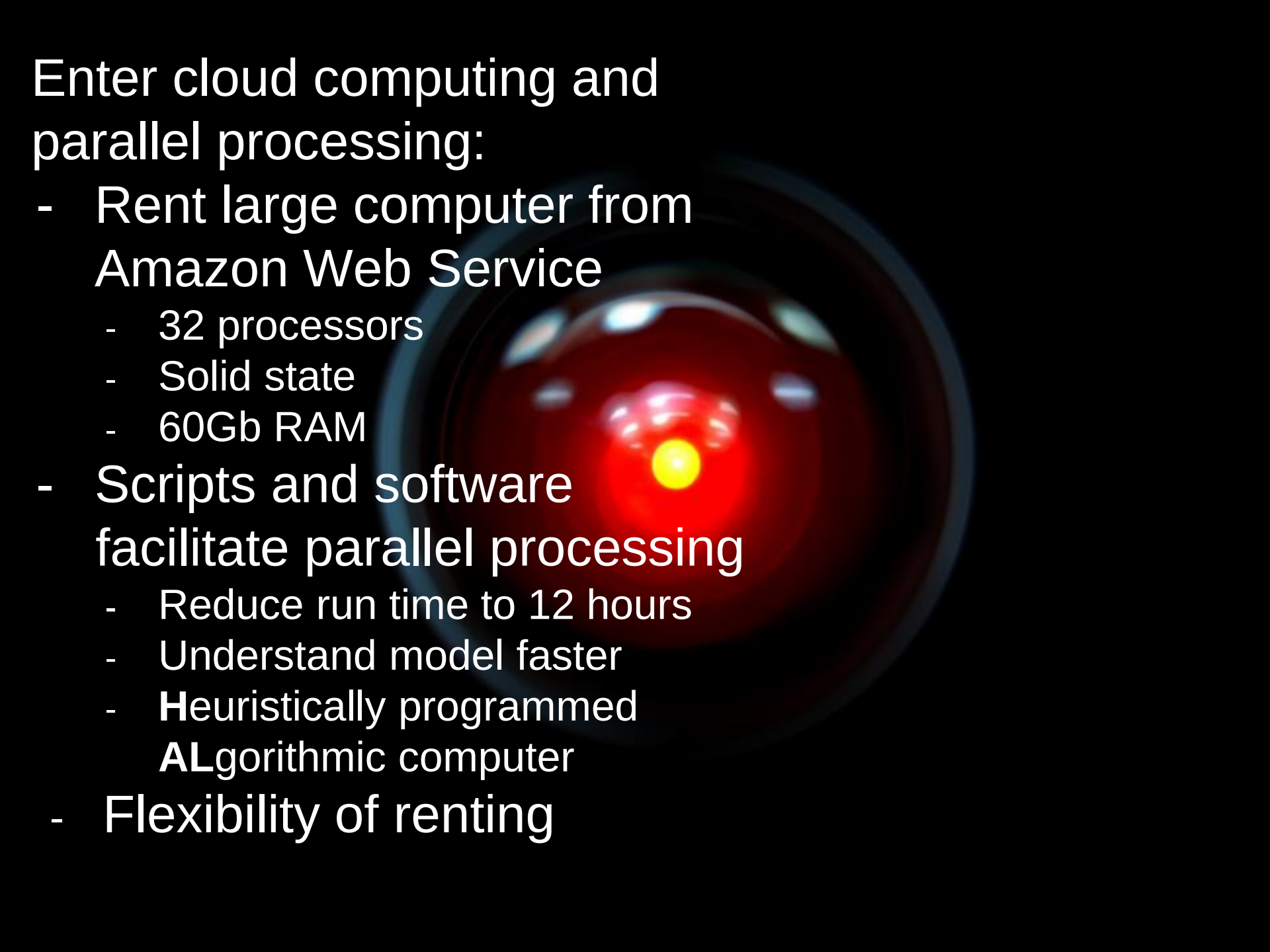

Global Sensitivity
Parameter
SMTMP_bsn
SMFMN_bsn
TIMP_bsn
SMFMX_bsn
SFTMP_bsn
SLSUBBSN_hru
ALPHA_BF_gw
CANMX_hru
GW_DELAY_gw
SURLAG_hru
SLSOIL_hru
GWQMN_gw
GW_REVAP_gw
RCHRG_DP_gw
USLE_K_sol
SOL_BD_sol
HRU_SLP_hru
ERORGP_hru
ESCO_hru
SOL_AWC_sol
FILTERW_mgt
ADJ_PKR_bsn
EPCO_hru
BIOMIX_mgt
USLE_P_mgt
OV_N_hru
SOL_K_sol
SOL_ALB_sol
CN2_mgt
PHOSKD_bsn
PPERCO_bsn
0.00
0.25
0.50
0.75
1.00
Relative Rank
Variable
Sediment annual mean
Sediment spring mean
Tot phosphorus annual mean
Tot phosphorus spring mean
Water yield annual mean
Water yield spring mean

Sensitivity Analysis

- Requires many model runs
- Example: adjusting GW_DELAY
  - each run takes 10 min
  - 25 different values
    = 4 hours
- For 50 parameters, might take 13 days to run

Enter cloud computing and parallel processing:

- Rent large computer from Amazon Web Service
  - 32 processors
  - Solid state
  - 60Gb RAM
- Scripts and software facilitate parallel processing
  - Reduce run time to 12 hours
  - Understand model faster
  - **H**euristically programmed **AL**gorithmic computer
- Flexibility of renting



Calibration

- Use monitoring data to train the model
- Optimize parameters to achieve accuracy metric
- Use SWAT-CUP software
  - Runs SWAT and automatically assesses fit
- Thousands of runs
- Manual assessment and adjustment
- Acceptable fit
  - Streamflow
  - Sediment
  - Phosphorus

Thanks for your attention
Questions?